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A BEHAVIORAL ANALYSIS OF THE ROLE OF VISUALS IN INSTRUCTION--STUDIES IN TELEVISED INSTRUCTION, THE ROLE OF VISUALS IN VERBAL LEARNING, REPORT 1.

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THIS STUDY WAS CONDUCTED TO DETERMINE HOW TO USE NONVERBAL, VISUAL MATERIALS (VISUALS) IN PROMOTING THE ACQUISITION, RETENTION, AND TRANSFER OF KNOWLEDGE. VISUALS WERE SELECTED FOR SEVERAL LEARNING SITUATIONS WHICH REQUIRED STIMULUS-ORIENTED STUDENT RESPONSES. STUDENTS WERE REQUIRED TO PRACTICE THEIR LEARNING ACTIVITIES WITH THESE VISUALS, MAKING BOTH "CRITERION" RESPONSES, DESIGNATED BY LESSON OBJECTIVES, AND INSTRUMENTAL "INTERMEDIARY" RESPONSES NECESSARY FOR TOTAL OBJECTIVE ACQUISITION. TWO BASIC FUNCTIONS OF THE VISUALS WERE IDENTIFIED--(1) THEY COULD BE USED TO CUE AND REINFORCE SPECIFIC RESPONSES, ADDING TO THE PROBABILITY OF STUDENT ACQUISITION AND RETENTION, AND (2) THEY COULD BE USED AS EXAMPLES IN ORDER TO FOSTER GENERALIZATION OF RESPONSES TO NEW SITUATIONS (TRANSFER), OR TO ESTABLISH BASIC UNDERSTANDING. (REFER TO ACCESSION NUMBERS ED 003 212 AND ED 003 213 FOR ADDITIONAL INFORMATION ON THE ROLE OF VISUALS IN INSTRUCTION.) (JH)

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STUDIES IN TELEVISED INSTRUCTION
the role of visuals in verbal learning

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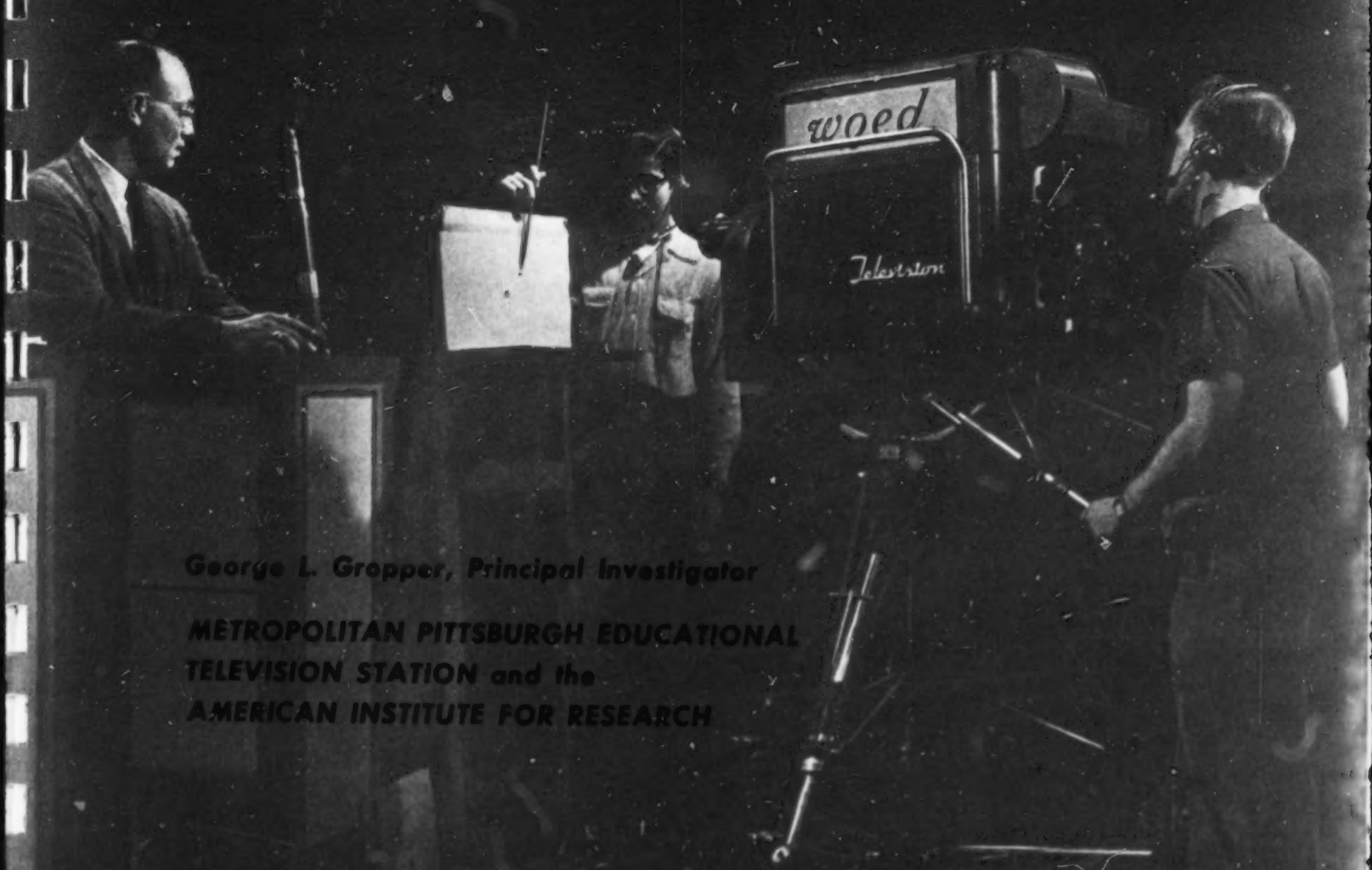
A BEHAVIORAL ANALYSIS OF THE ROLE OF VISUALS IN INSTRUCTION



George L. Gropper, Principal Investigator

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January 1963 - Pittsburgh, Pennsylvania

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FOREWORD

This report is the first in a series describing a research project investigating the use of visuals in instruction. The project, titled "Instructional Techniques for Improving Student Understanding of Principles Illustrated in Science Demonstrations," was made possible by a grant from the United States Office of Education under title VII of the National Defense Education Act of 1958.

Preliminary ideas describing possible roles which visuals might play in teaching facts and concepts were formulated during the planning phase of this project. Following the completion of an initial experiment, the ideas were amplified for presentation in this report which represents a preliminary attempt to provide a behavioral analysis of the role of non-verbal, visual materials in instruction.

Robert Gagné, Robert Glaser, David Klaus, Gerard Kress, and Harris Shettel of the American Institute for Research generously devoted their time reviewing the ideas tentatively proposed in this report. Their critical review was most helpful and greatly appreciated.

George L. Gropper
AMERICAN INSTITUTE FOR RESEARCH
January 1963

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INTRODUCTION

Instruction in most academic subject matters is typically offered by means of presentations which are a highly complex blend of words and pictures. The formal name we commonly use to describe this blend is "audio-visual instruction". It appears to make little difference for the effectiveness of instruction whether audio-visual presentations are offered live in the classroom or "canned" on film or TV. All these media have been shown to be capable of providing instruction with an appreciable, if varying, measure of effectiveness. Some of the variation in effectiveness may be due to the fact that words and pictures are often substituted one for the other with little apparent rationale. It is important to consider whether and under what conditions such substitution may be appropriate and feasible. It is also of interest to identify the conditions under which words and pictures have unique contributions to make and under which one or the other can do a more effective job of attaining a given instructional objective. If principles and practical guidelines for the preparation of audio-visual materials are to be formulated, theory and research must be concerned with the roles which both visual and verbal materials can play in teaching academic subject matters.

This paper contains some proposals for an analysis of the behavior which occurs during learning from audio-visual materials. These proposals were put together in preliminary form to provide an orientation for research on the role of visuals in instruction. They are, therefore, necessarily incomplete and tentative but are offered in this form because they may be useful in stimulating appropriate research questions in an important but still hazy area. The present discussion will concern itself primarily with the role of visual materials in teaching academic subject matter. An attempt will be made to identify some of the functions which visual materials may share with verbal materials and those which visual materials may more appropriately retain for themselves. The term "visual materials" is meant to include graphic, pictorial, or demonstrational presentations.

In order that available principles of learning may more easily be translated to the practical audio-visual setting, learning from non-verbal, visual materials will be described in terms of an objective, stimulus-response language. Using the language

and spirit of behavior analysis can, in addition, facilitate the formulation of propositions about learning from audio-visual presentations which are amenable to empirical testing. What we propose to explore is how non-verbal, visual materials may be used to promote the acquisition, retention, and transfer of the responses we define as knowledge.

CONTROLLING STUDENT RESPONSE BY VISUAL PRESENTATIONS

There have been converging trends in recent research on instructional films, educational television, and teaching machines. Research in all three media can be characterized by the increasingly more frequent emphasis on student response during the learning process. The value for learning of active student participation has been repeatedly demonstrated in a wide variety of instructional contexts. During later stages of this research on student response, attention has centered on techniques for guiding and controlling the responses which students make. Systematic efforts to exercise explicit control over the specific responses made by students found its culmination in programmed instruction.

Common to instruction by means of the film, television, and teaching machine media was: (1) an insistence on active student responding, either overtly or covertly, as an important condition for learning; and (2) systematic efforts to create and present stimulus or display conditions which would not only produce student responding but would also increase the probability that the responses made would be the specific, desired responses. The outcome of this approach was to bring specified responses under the control of specified stimuli, which, stated in a fairly abstract way, is the aim of all instruction. Put somewhat more concretely, students were required to practice specified behavior in appropriate contexts. They were encouraged to practice saying the correct words in response to relevant questions, or they practiced filling in the blanks in sentences with words which completed those sentences. In learning a variety of academic subject matters, explicit student verbal behavior, for example, thus came under the control of explicit verbal stimuli. In learning complex sequential procedures, explicit perceptual-motor behavior similarly came under the control of explicit verbal and/or visual stimuli.

This notion of systematically specifying the responses to be practiced in the presence of particular stimuli can be applied in those situations which employ visuals in the teaching of facts and concepts. As will be discussed, it is possible in an explicit way to bring student responses under the control of non-verbal, visual materials. While it seems desirable to do this, it has not typically been done. When graphic, pictorial, or demonstrational materials are employed to teach facts and concepts, it is often assumed that the visual presentation "conveys information" to the student. Systematic efforts are not generally made to specify what the overt or covert responses are which students are expected to make to specific visual features of the presentation. Nor are efforts made to require students to make such responses actively and in an explicit way.

When the student completes a blank in a sentence, either overtly by writing the answer on paper or by saying it aloud, or covertly by saying it to himself, he does so because we have instructed him to do so and because we have created an appropriate occasion for him to do so. His response is explicit as a result of the measures we have taken to encourage it. It is, of course, recognized that there may also be implicit responding either as a part of or in addition to the behavior that we try to control. When such implicit responses are made, their precise nature and the features of the presentation which prompt their occurrence is largely unspecified. While it may be of some importance in certain kinds of theoretical interpretations of behavior to be concerned about these implicit responses, in the instructional context, regardless of what these implicit responses might be, the primary concern has to be with the explicit responses students make. Otherwise we would be handicapped in trying to control the learning process. We gain control over the learning process only when we can identify stimuli and when we can observe or measure responses, either directly or indirectly.

What we already know about controlling responses by means of verbal material, if suitably applied to the audio-visual setting, can go a long way toward describing the functional relationship between visual materials and student response to them. No new principles of learning are likely to be needed to account for audio-visual instruction. The discussion which follows in the remainder of this section, while specific to "response to visuals," derives from a more general analysis of instruction. It makes the assumption that the responses to visual presentations can be and should be specified and that students be required to make them in explicit ways during instruction.

Mode of Response to Non-Verbal, Visual Materials

In teaching academic subject matter, the active and explicit responses a student may be required to make to non-verbal, visual materials include: verbal responses, visual discriminations, or non-verbal motor responses. Although the stimulus is visual, systematic control can be exercised over student responses in any of these modes. The student can be stimulated to practice those responses or classes of responses which will prepare him to perform as we wish him to perform either on a test or beyond the classroom.

Verbal responses. - The student can be stimulated to attach a verbal label to features of a presentation, to describe those features, or to interpret them. For example, in teaching the principle that "all matter expands when heat is applied to it," the expansion of a solid, a liquid, and a gas might be illustrated. With the aid of magnification techniques, the student can be shown the expansion of a metal bar as it is being heated. He may on the basis of the presentation be required to practice saying to himself, out loud, or on paper "the bar expands when it is heated." Or he may practice saying, "the water rises in the tube because the water in the flask expanded when it was heated." Or he may practice saying about a balloon attached to a flask filled only with air, "the balloon got larger because the air in the flask expanded when it was heated." The practice of these descriptive and interpretive verbal responses can be required of the student as each of these demonstrations proceeds.

Visual discriminations. - As an alternative to or in addition to these verbal responses, the student may be stimulated to practice visual discriminations about these same events. He may, for example, make a discrimination about the level of water in the tube before and after the application of heat to the flask. To be sure that he has actually made the appropriate discrimination, he may be required to make an overt response indicative of this attainment. He may, for example, select from alternative choices in a work book the illustration with the appropriate water level. By pointing to an appropriate reading on a scale, the student can demonstrate that he has acquired a discrimination about the relative differences in apparent loss of weight for submerged objects of differing size. A technician can demonstrate that he has made the proper discrimination between a "resistor" and a "capacitor" by selecting one rather than the other. During a visual presentation the student can be required to indicate behaviorally that an appropriate discrimination has

been attained. The behavioral manifestation represents a measure of the facts and concepts the student has acquired by means of the visual discrimination training.

Non-verbal, motor responses. - Still another mode of response the student may be required to exhibit during a visual presentation is the non-verbal motor response. The student may be stimulated to reproduce elements from a static or dynamic, procedural presentation. He may copy visually perceived physical objects, as for example, using ruler and pencil to draw an isoceles triangle shown him or using a compass to draw a circle shown him. He may be required, following the presentation and in the absence of the visual, to perform a science experiment illustrating, for example, the expansion phenomenon discussed above. Similarly, during the presentation he may be required, in the absence of features on a map, to locate rail centers or to draw in the connecting links. Or he may be required to plot a function on graph paper.

Whether the student practices verbal responses, visual discrimihations, or motor responses during a visual presentation is determined by lesson objectives and by the strategy followed in trying to attain them. It is not necessary to rely on the assumption that the visual presentation has "communicated information" to the student if he is required to practice specified responses in any of these modes. When, in particular, responses are overtly made and a record of them is kept, these provide tangible evidence of how the visual has functioned in controlling the student's learning behavior.

Functions of Responses Made During Visual Presentations

Visual objects and events may be used to promote student practice of criterion responses and intermediary responses. Designated as criterion responses are those responses the student is expected to be able to make on an achievement test or in an out-of-the-classroom situation. Intermediary responses are those responses which are practiced in the learning situation primarily to facilitate student acquisition of criterion responses. Although in actual practice the two types may occur in interaction, it is nevertheless useful to distinguish between them.

Criterion responses. - Visual as well as verbal presentations can be used to stimulate practice of the actual responses the student is expected to make either

in taking an achievement test or in an applied out-of-the-classroom situation. If the student is expected to be able to say what happens to all matter when it is heated, he may be given the opportunity to practice saying precisely that. He might be required to do so during one or more of the demonstrations illustrating the expansion of each of the three specific types of matter. Or, if he were merely required to be able to assert what happens to each of these three specific types of matter, he would be encouraged to practice making the responses describing the events of each demonstration rather than practice stating the more general proposition. In either case, the visual presentation serves to promote the practice of the actual responses the student is being prepared to make beyond the learning situation.

Intermediary responses. - Before the student can practice saying that "all matter expands when heated," he must know or have had prior practice in the correct use of the verbal response "matter" or the verbal response "expands." He must be able to make these responses before he can make the criterion response. In this sense these responses are called intermediary responses. He must, to take an example discussed earlier, be able to discriminate between the levels of water in the tube inserted in a flask of water, before and after heat is applied to it. He must also be able to make the discrimination between other causes of the rise of the water level, i.e., that it is due to the expansion of the water and that it is not due to the effect of boiling.

The student must be able to make these intermediary differential responses to the relevant static components of a visual or to the relevant on-going events of a demonstration before he is able to acquire the criterion responses which constitute understanding of the facts and concepts the visual is intended to illustrate. Such visual discriminations are a sub-class of intermediary responses which are highly important for the effective use of visual presentations.

Discriminations About Features of Visual Presentations

A static picture or a dynamic visual demonstration may contain many stimulus-features. Visuals differ in the density of such features and in the ease or difficulty with which these features may be discriminated one from the other. The effectiveness of a visual presentation in part depends on the ease or difficulty the student has in making such discriminations and in part on his ability to make

further differential responses to them. The student must be able to identify and attend to the relevant components of a static picture or to the relevant components and events of an ongoing demonstration. He must be able to discriminate between the anode and the cathode in an illustration before he can go on to make other appropriate responses to them, as for example, label them correctly. He must be able to discriminate the area of a pie chart that applies to "military expenditures" as opposed to the area which applies to "educational expenditures" if he is then to be able to describe the relative amounts of money spent by a government in different categories.

For a demonstration or a static visual to be effective, the student must be able to identify, attend to, and respond differentially to: (1) the topographical or physical units of the presentation; (2) properties of these units and (3) relations among the units and their properties. A primary purpose in requiring the ability to make discrimination responses to a visual presentation is to delimit the physical boundaries of the unit we deem relevant and to which we wish the student to respond. We do this to restrict the student's response to just that unit and not to others. We also try to restrict his responses to just those properties of the unit we consider relevant. And we try to restrict his responses to just those relationships among units relevant to the purpose of the presentation.

To illustrate the bending properties of a bi-metal bar, standard laboratory demonstration equipment may be used. This may include a bi-metal bar, which, upon being bent can make electrical contact and ring a bell. The student must be able to identify and to respond to the following topographical or physical units: the bi-metal bar itself may constitute one unit; the battery, electrical wiring, and the bell may constitute another unit. The student must be able to recognize that the electrical events of the demonstration are self-contained and occur as the result of the bending of the bi-metal bar. Unless these discriminations are made, he may then subsequently fail to make further appropriate responses to the demonstration and mistakenly attribute the ringing of the bell directly to the flame from the match, as did some seventh and eighth graders in an actual experiment. (Depending on our purposes, the units could be made smaller and the student could be required to identify parts of the bi-metal bar.) In addition to delimiting these topographical units, the student must also be able to identify their spatial, sequential. or temporal arrangements: flame under the bar; bending of the bar; electrical contact made; and ringing of the bell.

Discrimination of presentation units. - To be able to respond appropriately and differentially to the relevant features of the visual presentation, the student must be able to distinguish the discrete boundaries between two or more separate units. It may further be necessary for him to be able to identify discrete boundaries between parts of a unit. Essentially this means being able to respond to smaller units. But it may also be necessary for him to be able to identify how the parts are related to one another and to the whole unit. This might simply mean recognizing their spatial arrangement as, for example, in recognizing where particular parts of a carburetor are located.

Discrimination of properties of presentation units. - The student, in addition to being able to distinguish between units, must also be able to distinguish between the relevant and irrelevant properties of a single unit. The relevant property is of course determined by instructional purposes, and the student must be enabled to respond to it. He must be able to identify the relevant physical property whether it be size, shape, volume, color, direction, etc. Unless he can identify the relevant property of the unit, he may attend to and respond to an irrelevant property.

Discrimination of relationships between presentation units. - Similarly, the student must be enabled to identify and to attend to the relevant relationships in a visual presentation. This may simply mean attending to the spatial arrangement of units in a static visual or it may mean attending to the beginning and end of a demonstrational unit or to the order or sequence of events in a demonstration. It may mean, for example, recognizing that expansion follows the application of heat and contraction its removal.

Before the student can make appropriate responses to the visual presentation, he must first be capable of making these various discriminations. If the appropriate discrimination responses to the visual presentation are not already in his repertoire when he enters the learning situation, he must acquire them. Thus, he has either acquired them in the past or he acquires them through practice in the learning situation. He is further enabled to make the appropriate discriminations by the techniques employed by the demonstrator. The demonstrator can in some instances accomplish this by, for example, attaching a verbal label to a unit or property of a unit. Or he may use a variety of pointing techniques to accomplish the same end. By whatever

means the student is prepared to make the appropriate discriminations, once he is so prepared he is then ready to learn to make further responses to the visual presentation.

Amount of Response Practice

The amount of practice of criterion responses or of intermediary responses which students may be required to engage in during a presentation is determined by lesson objectives. If, for example, long-term recall is desired, the amount of practice may be considerably greater than if immediate comprehension is the goal. But this is a problem which is common to all forms of instruction, not just audio-visual instruction. However, how this problem interacts with the need for the acquisition of intermediary discrimination responses is of particular importance to instruction with graphic, pictorial, or demonstrational presentations and will concern us here.

The strength at which a discrimination may already exist in the student's repertory will be a consideration in determining how much response practice will be required. If the discriminations already exist at a suitable strength, little or no practice may be required and verbal or visual materials can be used to identify the relevant units. A printed label indicating the name of the unit or an oral identification of it may suffice. Similar verbal or visual labeling of the unit may be sufficient in many situations without student practice. It remains an empirical matter, however, to determine whether or not these discriminations can actually be made.

The way in which the discriminations are to be used, that is, their relation to the later behavior expected of the student, will also determine the extent to which the student may be required to practice making discriminations. There may be occasions when considerable discrimination practice is used to carry the burden of conveying understanding, with or without a subsequent verbal commentary. Understanding of concepts may in this instance be described as the ability to make appropriate discriminations. When this is the case, the discrimination responses made would, in terms of the definitions offered here, be criterion responses rather than intermediary responses. Here, what is conventionally described as verbal subject matter is taught by non-verbal, visual means.

In an experiment during the course of research on problems discussed in this paper, an entirely visual lesson on Archimedes' Law was programmed (in the teaching machine sense). Students practiced making discriminations about events in the demonstration, events which exhaustively illustrated the relationships between the relative size of submerged objects, the amount of water they displaced, and the apparent loss of weight for the different sized objects. At the conclusion of this visual lesson, students were able to select from pictorially presented alternatives what these relationships would be for new but similar events. They were also able to answer verbally presented questions about these same relationships. Practice of an entire range of discriminations involved in these relationships produced an understanding of Archimedes' Law. For example, on the basis of the visually programmed lesson students were prepared to predict correctly the change that would occur in pointer readings for objects attached to a hanging scale when the objects were weighed in air and in water. They were able to predict the relative amounts of overflow that would result from submerging objects of differing size. They were able to predict the relative apparent loss of weight for objects of different size. The amount of practice allotted to each of these and other discriminations was that which was judged sufficient to permit students to acquire an understanding of the concepts involved. Evidence that it was sufficient was the ability of students to make additional, correct predictions in similar but new situations. Less practice of these discriminations would have been possible if verbal material had been used to take over some of the same functions. In this demonstration on Archimedes' Law, had the purpose of the research not been to test the possibility of teaching facts and concepts solely by visual means, it might have been sufficient to identify the units and perhaps label them verbally, without the need to use discrimination training to develop understanding of the relevant relationships. Practice of verbal responses might equally well have served this latter objective.

In summary, we may say that during visual presentations the student may be required to practice making both the criterion responses designated by lesson objectives and the intermediary responses which are instrumental in their acquisition. Visuals and verbal materials both share the capability of providing the appropriate context for such practice. Quite important to the visual presentation is the necessity that the student at each step in the instructional sequence be able to make discriminations about relevant parts of the presentation and on the basis of these discriminations to make further appropriate differential responses to them.

Using Visuals to Control Responses

When a response is said to be under the control of a stimulus, what is meant is that the stimulus can influence the probability that a student will make the response. For example, when the student is asked, "what happens to matter when it is heated?", the student may reply that "matter expands when heated." This response is said to be under control of a verbal stimulus, namely, the question which the student was asked. Before receiving instruction, the student could not make the appropriate response to this question. The verbal response or answer was not under the control of the verbal stimulus or question. The probability that the student could answer the question was low. Following instruction, the appropriate verbal response was under the control of the verbal stimulus. The probability of its occurrence when the question was asked was high. The general aim of instruction is to increase what was an initially low probability of occurrence to a high probability of occurrence. When this happens, verbal responses <u>are</u> under the control of verbal stimuli.

The same analysis applies equally well to the use of visual materials. When the student is able to make discriminations among the relevant features of a visual presentation, those features can then be used to control further responses. Some visuals are used because responses which require practice in the learning situation are already under their control. The visuals can be used to prompt their occurrence. A magnified view of an expanding metal bar might be used as a visual prompt or cue for the response "expands." Through prior learning experiences the student had learned to make this response in the presence of the visually perceived physical event. If he had had no such prior experience, the response would not have been under control of the visual event, and the aim of instruction might be to bring it under such control.

THE CONTROL FUNCTIONS OF VISUALS

Two Basic Functions of Visuals

Visuals may be used to serve two basic functions in promoting the acquisition, retention, and transfer of responses. First, they may be used to cue and to reinforce

responses so that the responses may be acquired and retained. Second, they may be used as examples in order to foster generalization of responses to new situations, or in other words to establish understanding.

Visuals as cues and reinforcers. - An element or unit of a visual presentation may be used to promote the practice of particular responses if, on the one hand, the student identifies and attends to that element, and if, on the other hand, these responses are under the control of the element. When both these conditions are met, the element or unit of the visual presentation may be used to cue or prompt the occurrence of the response. It may also be used to reinforce or provide the student with confirmation about the correctness of his response.

The role of visuals as cues and reinforcers can be illustrated by the following example. The demonstration of a solid object expanding as it is being heated can serve to cue or prompt the response "expands." A second use of the demonstration might involve asking the student before the heat were actually applied to predict what would occur if heat were applied to the object. The visually perceived expansion following the application of heat would serve a reinforcement or confirmation function for the student. It would indicate to him that his response "it will expand" was correct. Its function here is similar to that provided by verbally telling the student "it will expand" or by verbally telling him that he was correct.

Visuals as examples. - Many types of visuals are used solely because of their capacity to cue or prompt particular responses. The visuals and their physical format themselves bear no logical relation to the subject matter being taught. Graphs, charts, diagrams all share this property; they are used primarily because they can serve as cues for particular responses we wish the student to make. A bar graph can cue responses about absolute or relative amounts of X in any variety of subject matters. The format of the visual is not dictated by the subject matter; it is only X or the referent of the visual which is relevant to the subject matter.

In instruction, the visual example is highly relevant to the subject matter and, in addition, serves more than a cuing or reinforcing function. The examples of expanding solids, liquids, or gases are relevant to physical science. They serve to build student understanding of the concept they are intended to illustrate. They do so by providing an opportunity for the student to respond appropriately to a variety of examples all illustrating the same concept. The generalization of

responses to new but relevant situations is thereby facilitated. When the student responds appropriately to the three separate and different instances of the expansion of matter, he is being aided to arrive at the generalization that "all matter expands when heated." The visual example, along with the verbal example, is a unit on a generalization dimension. In addition to cuing or reinforcing particular responses, the visual example fosters the acquisition of a generalized response.

Criterion and Intermediary Visuals

Some visuals are used because responses which require practice in the learning situation are already under their control. The visuals can therefore be used to prompt their occurrence. Still other visuals are used because prescribed responses can readily be brought under their control. Both these first two types are used to cue responses so that control over these responses can then pass to other stimuli, usually verbal stimuli. We shall refer to these types of visuals as intermediary visuals. Still other visuals are used because the purpose of instruction is to bring particular responses under their control. We shall refer to this type of visual as criterion visuals.

Criterion visuals. - The use of visual presentations appears to be desirable in those subject matters in which visually perceived physical objects and events are integral parts of the criterion situation. Upon completing instruction the student may be expected to be able to observe, describe, interpret, or reconstruct them. If, for example, students upon leaving the instructional setting are expected to be able to use litmus paper appropriately, to identify a Van Gogh, to use a circuit diagram, etc., experience in the learning situation with the actual phenomena, with similar phenomena, or even with visual representations of those phenomena, can foster the appropriate transfer. This is so because transfer is known to be facilitated when similar elements are shared in both the learning and criterion situations. Indirect evidence bearing on this point is available from studies showing achievement test results to be higher the more similar the learning and testing situation are. Thus, it in general appears desirable that visuals which will be experienced in the criterion situation be employed in the learning situation whenever possible.

The primary purpose in including criterion visuals, or visuals which are similar to them along some relevant dimension, is to provide an occasion for student practice of appropriate responses to them. In so doing these responses are thereby

brought under their control. The student learns to make appropriate discriminations, verbal responses, or non-verbal motor responses in their presence. The use of criterion visuals in the learning situation facilitates the acquisition of appropriate responses to these visuals and the transfer of these responses beyond the learning situation.

Verbal materials are sometimes substituted in the learning situation for criterion visuals. When this is so, it is important to determine whether the words used are substitutable for and can do as effective or more effective a job than the visual events. To take a concrete case, can practice of responses made to color words during learning provide for effective transfer of these same responses to the actual colors in the criterion situation? Pre-testing of lesson material can be used to determine whether such transfer to the visual criterion situation will in fact occur. It is reasonable to assume on a priori grounds, however, that there are situations or occasions where the use of words, which are more abstract and more general, can foster transfer of responses to a broader range of visual criterion situations than the more concrete, the more specific visual can. The verbal substitute would be indicated if the student were expected to encounter a variety of similar but perhaps superficially slightly different criterion situations (e.g., all shades of red). There may on the other hand be situations where the visual stimulus in the criterion situation is highly specific (e.g., a specific shade of red). The use of the more general verbal substitute would then appear to be inappropriate. In any practical situation, detailed analysis of such possibilities should be made to determine the relevance and appropriateness of using criterion visuals or verbal substitutes for them.

Intermediary visuals. - In contrast to the criterion visual which initially has no control over particular responses and only gains control after learning has occurred, the intermediary visual does have such initial control. Responses are already under its control or can readily be brought under its control. The intermediary visual is used for logistical and instrumental reasons. It may not be integral to the criterion situation and is therefore used primarily to cue or prompt responses so that control over these responses may be transferred to other stimuli. These other stimuli are generally verbal. For example, at the conclusion of a demonstration on the expansion of a solid the student may be expected to answer the verbal question "what happens to solids when they are heated?". When he is able to respond correctly, we say that the appropriate response is under the control of

the verbal stimulus, i.e., the question. Before the demonstration the student cannot answer the question and his behavior is not under such verbal control. During the demonstration the correct responses are, however, under the control of the visual stimulus events and the demonstration is used so that the control may be transferred to the verbal stimulus.

The visual presentation which is not relevant to the subject matter and not integral to the criterion situation is, nevertheless, used to cue responses so that they may be brought under the control of other stimulus events which are relevant and integral to the criterion situation. Graphic aids are a case in point. They are not used because the student is expected to respond to them on a test or out of the classroom. Only if the purpose of a lesson was to teach students <u>about</u> bar graphs, for example, would the bar graph appear in the criterion or out-of-the-classroom situation. The bar graph is generally used as a means of aiding the student to make responses which can then be brought under the control of other, usually verbal stimuli.

The intermediary visual is, thus, used because of its capacity, based on the student's past learning history, to cue responses and thereby expedite the course of learning. Visuals which do not already have this capacity may still be used to serve this logistical cuing function, if the responses to be acquired can readily be brought under their control. The visual is then used to cue responses so that control over them can be transferred to other stimuli, the criterion stimuli.

Considerations in Using Intermediary Visuals

Both visual materials and verbal materials share the capability of serving as intermediary stimuli to cue and to reinforce responses. Since the intermediary stimulus fulfills an essentially logistical function, the criteria for selecting it and evaluating its usefulness are in the main logistical. As a general statement we might say that the stimulus which is chosen will be one which can most efficiently: (a) cue and reinforce desired responses or (b) with little difficulty be made capable of cuing and reinforcing these responses. Such time measures as response latency or acquisition time may be considered appropriate measures in this regard. As to

whether the stimulus should be a verbal stimulus or a non-verbal, visual stimulus, some of the following, further considerations may offer some guidelines.

In a particular instructional setting and for a particular instructional purpose the efficiency and effectiveness of stimuli, whether visual or verbal, to serve a cuing or reinforcing function, in part, appear to depend on such considerations as the number of discriminable properties they possess. They also appear to depend on the number of discriminations about these properties which are in the student's repertory. The more discriminations that can be made, the more likely that they may create potential competition for the student's attention and subsequent response. Also determining the effectiveness of a stimulus is the degree of control it has over the desired responses (i.e., the probability of the responses being made to it) and the degree of control it has over potentially competing responses. The more univocally a given stimulus will cue given responses, the more efficient is learning likely to be. The more responses there are under the control of a stimulus the greater the likelihood that the stimulus might cue responses which can compete with the desired response.

It may well be an empirical matter whether a particular visual or its verbal equivalent can more univocally cue a particular verbal response. Relatively simple visual materials probably have cue value for fewer responses than do their verbal counterpart. Visual materials may, on the other hand, be more complex involving many discriminations and have cue-value for many responses. The density of cues contained in visuals may, on the basis of considerations already discussed, impede learning efficiency. If a visual contains many cues and these cues are for responses which compete with those desired at a particular time and for a particular purpose, then the visual may prove of no value. If, however, student attention is directed only to that portion of the visual event relevant to a designated response, and this enables the student to make only that response, then there is some justification for using the visual. Not only can it lead to the single desired response, but it may also, when needed, lead to other desired responses. By controlling student attention to only that portion of the visual which is relevant at that time, each response can be cued when needed. Thus, the dense presentation containing many cues

can prove effective or ineffective depending on usage. This serial production of responses to a single, dense visual presentation can be more efficient (in the sense of the time required to facilitate the acquisition of X number of responses) than a counterpart verbal presentation. The verbal presentation may require an uneconomical number of words and require an uneconomical amount of time in relation to the number of responses it enables the student to acquire. In this sense the visual may do a more efficient job of teaching than its verbal counterpart.

There is another advantage of the dense presentation over and above its capacity to cue a number of discrete responses serially. Relationships among the individual visual cues may readily serve further as cues for responses about those relationships. Visual portrayal of some kinds of relationship may be more effective in this regard than words because of the visual's spatial or sequential properties. Many relevant cues about complex relationships can be more briefly presented both topographically and temporally. Such graphic aids as charts or diagrams come readily to mind in this regard. This use of a dense visual presentation can prove more efficient as measured by the time required to facilitate the practice of relevant responses.

Many of the often cited advantages of essentially filmic or pictorial media can be reinterpreted in terms of their capacities to serve the cuing function. Included among these advantages of films or TV are the capability of: restricting the visual field to include only predesignated parts of a visual presentation; distorting stimuli, as for example in enlargements or magnification; or simulating phenomena, as in the use of animation. A chief value of all these techniques lies in their capacity to do a better job of cuing particular responses. This means increasing the probability that viewers will make these responses rather than other potentially competing responses.

Other often cited considerations about visual media can also be reinterpreted in terms of the cuing function. When the "relevance of a visual to the commentary" is discussed, what may be implied is whether the visual and verbal stimuli are cuing the same responses or potentially competing responses. Similar considerations

apply to whether or not the "visual supports the commentary" or vice versa. By reinterpreting such terms in cue-response language, it is perhaps, easier to analyze whether a presentation is doing the job it was intended to do or whether its effects might be indifferent or even competing.

In summary, we have described two basic functions which visuals fulfill: to cue and to reinforce responses and to serve as an example along a generalization dimension. Visuals, whether as cues or as examples, serve either as criterion or as intermediary stimuli. This section has discussed some considerations which might suggest the use of visual rather than verbal cues for particular instructional objectives. In the next section we shall be concerned with some of the potential values in using visual rather than verbal examples.

POTENTIALITIES OF THE VISUAL MODE

In instruction, examples aid the student to attain an understanding of the concept they illustrate. For this purpose, some examples can be presented either visually or described in verbal terms. Even in the physical sciences, where visually perceived physical events are an integral and relevant part of the subject matter, examples may be presented in either of these two modes. On what bases should the visual rather than the verbal example be selected?

There readily come to mind a number of reasons which are suggestive as to why a visual example might be less preferable. First, since knowledge in most academic subject matters, as currently taught, is essentially verbal, the generalized responses we wish students to make are mostly verbal responses. Are there any a priori reasons why we should expect the generalized response to be acquired more readily on the basis of a visual rather than a verbal example? This raises the general problem of how easily transfer occurs from one mode to another and whether or not transfer within a single mode might not more readily occur than transfer between different modes.

Return on the use of time is a second consideration. To present an example visually in such subject matters as science may require considerable amounts of time. Science demonstrations are often of long duration. If these presentations are considered in terms of the number of responses they aid students to acquire, their use may in this logistical sense be uneconomical. The same example described in words might make for the more economical use of available time.

Thirdly, all examples whether visual or verbal, are, in comparison to the concept they illustrate, highly specific. There are, however, degrees of specificity. The visual example appears to be at the extreme of the continuum. The verbally stated example, even though more specific than the principle it illustrates, can be more general than its visual counterpart. To illustrate the verbal generalization that "men's clothing is made of cloth" we might cite the single verbal example that "men's suits are made of cloth." This is at a higher level of generality than can be attained if it were illustrated visually. Presented visually, a single man's

suit or even a large number of them might be shown at the same time. The visual example or series of examples cannot, however, assert such qualifiers as "all" or "always" or even "most." To arrive at a relatively low level generalization might therefore require induction from numerous visual examples. This being the case, several visual examples might be required to equal one verbal example in generating understanding of a concept. One verbal example might conceivably be worth two, three, or more visual examples and perhaps constitute a more efficient use of available instructional time.

Or are there considerations which make an example presented in the visual mode worth the extra time they may require?

Comparisons of Sensory Modes

Considerable research has been conducted aimed at determining whether "information" received over one sensory channel might be superior to that received over another. So, for example, comparisons have been made of achievement test results of students who learned from verbal materials presented in printed form for the video channel with those of students who learned from the same verbal materials presented orally for the audio channel. Studies have also assessed the effect of combining these sensory channels. Comparisons have also been made of instruction via pictures with instruction via words.

In assessing the significance of findings in studies of this kind, it should be borne in mind that comparisons of presentations which do not differ from one another in a predetermined and systematic way tend to provide results of uncertain generality. They may merely reflect the success with which a particular investigation had in preparing a particular version of a lesson. The minimal requirement that should be met in comparing non-systematically varied versions of lessons presented over different channels is that alternative versions be demonstrated equally capable of bringing criterion responses to strength. Comparisons of channels which are not response-oriented and which do not provide an analytic description of the behavior involved during audio-visual instruction and of the techniques to prompt it, fail to meet this minimum. Studies of sensory channel comparisons which are not prepared in this way typically provide differences between groups which are not easily attributed to any differences in the nature of channels. They may merely reflect, in an undetermined way, the differential success which each version may have had

in cuing desired responses. The technique of comparing combined channel presentation with one channel presentation is less subject to this criticism, but here too specification of desired behavior and the techniques for prompting it are generally not made.

Previous sections in this paper have offered some suggestions as to the responses which occur during visual presentations and how visuals may be used to aid students to practice them under specified, controlled conditions. Over and above these considerations, are there properties of the visual example and of "visual experience" in general which facilitate the acquisition, retention, and transfer of knowledge? What follows are some hypotheses as to what some of the properties of the visual mode are which may favor its use in instruction.

Visual Reinforcement

In analyzing the confirmation function in programmed instruction, we can see an analogue for what appears to be a potent and ubiquitous phenomena, namely, reinforcement in the visual mode. When a student completes his task of constructing or selecting an answer, he then looks for the right answer and compares his own answer (or product) with the one designated as the standard. The steps in the student's receiving reinforcement (in the confirmation sense) consist of looking for and identifying the consequences of his behavior and comparing these consequences with a standard set by the instructor.

Out of the classroom the student also constantly observes the consequences of his behavior. When tying his shoelaces, he observes the properly tied knot (the consequence of his tying behavior) and the further consequence: his shoes don't slip off his feet. When he holds his soup spoon level, the soup doesn't drip on his clothes. Not only does he observe the products and consequences of such behaviors, he sometimes actively looks for them. When shaving he turns his face in several directions to make sure how clean a job he did. How actively he attends to and observes these consequences depends no doubt on such factors as: how recently acquired the behaviors producing the consequences are; whether the behavior has as yet been mastered; how critical the consequences may be for adapting to the environment; and whether or not discriminable changes in consequences occur constituting

deviation from standards created by past experience. As in the examples cited above, consequences consist of attained goals or of avoided aversive conditions.

The consequences of behavior are said to reinforce that behavior; that is, the behavior is more likely to recur under similar circumstances. Generalizing from this, we may say that the behavior of "observing and looking for consequences" also gets reinforced. If the student actively looks at the consequences of his shaving behavior, the results are usually better shaves. Better shaves, if we can believe the ads, lead to more home runs, prettier dates, etc. In a sense, the student "learns to look for confirmation" just as he may "learn to learn." "Looking for confirmation" not only reinforces other behavior but gets reinforced itself, both in the confirmation and reward sense (if it leads to desired goals).

Although confirmation is also received (and also actively sought) by auditory and kinesthetic means, the visual mode appears to occupy a dominant position. The sheer frequency with which the visual confirming behaviors occur contributes to its being strongly acquired and creates opportunities for its generalization to a vast range of new situations. Not only does it generalize to new situations the student himself encounters, but it may also generalize to situations which other people encounter. The student observes visually not only the consequences of his own behavior but also the behavior of other people both in the classroom and out.

We can reinterpret "seeing <u>is</u> believing" to mean that a generalized response is made to visual events. Visual events provide veridical evidence about the consequences of the student's behavior and of other people's behavior. The "truth" of the evidence lies in the goals it makes possible and the pitfalls it helps the student to avoid.

The visual example in instruction provides just another occasion for the student to emit a generalized visual "confirming" response. But, it can be a useful occasion, if, for example, students are allowed (in science instruction) to predict the outcome of events and to receive visual confirmation of their predictions. Because of the ubiquitous and potent role that visual confirmation normally plays out of the classroom, using it thus in the classroom may influence the effectiveness of instruction. Such visual confirmation may, indeed, be more effective than a verbal description of the outcome or than being told that one is right.

An experimental assessment of this effectiveness could readily be made in terms of such conventional measures as the number of trials required to bring a response to strength or in its resistance to extinction as a function of the use of different types of reinforcement.

Generalized Responses to Visual Examples

Generalized responses can be acquired on the basis of visual experience. Pedestrians learn not to cross the street against a red light at this corner and also at the next. They are then able to make this response not only in Pittsburgh but also in New York or Boston. They are also able to verbalize about their experience and to tell their children not to cross against a red light. When visual experience is suitably "programmed," a generalized response can be acquired and made in appropriate new situations. Moreover, transfer from one mode to the next seems possible (e.g., verbalizing about non-verbal behavior). And, in the classroom, as was pointed out earlier, if a visual lesson is suitably programmed, the student can answer both pictorially and verbally stated questions about such conceptual phenomena as Archimedes' Law. But it does not appear to be the case that all visual experience either in the classroom or out of the classroom is suitably programmed so that generalized responses are readily acquired and made to subsequent examples calling for the same responses. The conditions which would permit this to occur appear to be those which facilitate discriminations about similarities and dissimilarities in visual situations. Instructional settings which provide these conditions can facilitate the acquisition and subsequent practice of generalized responses.

The prevalence of visual experience provides frequent opportunity for the practice of "looking for similarities in visual situations" in much the same way that it provides opportunities to "look-for-confirmation." It does not appear to be the case, however, that active search for similarities and dissimilarities in visual situations approaches the prevalence of the "looking-for-confirmation" behavior. Potentially rewarding research might be conducted to determine how to train people actively to search for similarities in visual examples or verbally described examples as a means of solving problems or of gaining understanding of principles and concepts.

Whether people perceive and respond appropriately to examples or actively analyze them, the likelihood of "generalized response" being made to a new instance

would appear to be a function of similarity among instances or examples. The greater the similarity among examples, the more likely will the generalized response be readily acquired and then made to new examples. The requirement of a high degree of similarity can create problems for those developing instructional sequences when the examples, as in science, are highly dissimilar from a superficial visual or structural point of view. For example, the demonstrations illustrating the expansion of solids, liquids, and gases, which were cited earlier, bear only slight structural similarity to one another. Yet all are used functionally to illustrate the same concept, namely, the expansion of matter when it is heated. As we shall see in the next section on visual representation, direct, indirect, and analogous examples can be used to illustrate concepts. All three types serve as examples to aid in the acquisition of a generalized response. A mixture of such types of examples, bearing little superficial or structural similarity to one another may require additional instructional sequences so that students can respond to the appropriate functional similarity. They need to be able to make discriminations about the dimensions of the example, whether structural or functional, which make it similar to another example and the appropriate occasion for the same generalized response.

The relative ease or difficulty in making discriminations about properties of visual or verbal examples permitting the recognition of similarities will be another factor in determining which of the two types might more beneficially be used. Little data as yet exists to provide guidelines to make a general determination about this problem. It would appear, however, that variations among verbal examples might be more readily manipulated providing discriminable degrees of similarity. Variations among visual examples, on the other hand, may be more restricted by the physical or structural properties of their contents. This may place limitations on the amount of control possible over the dimension of similarity. Should this, in fact, be the case, then greater "programming" skill might be required in the use of visual examples to help the student acquire appropriate discriminations. On the other hand, the use of such simulation techniques as animation, whereby detailed control can be exercised over the degrees of similarity among events, may create ideal conditions for enabling the student to acquire appropriate visual discriminations.

When the student enters any particular instructional setting, he brings with him an ample repertoire of visual discriminations about physical objects acquired through past learning. He has most likely learned, among other things, to

discriminate appropriately among shapes, sizes, directions, etc. It is this type of repertoire which can be exploited in the classroom. These objects or their properties can serve as intermediary cues facilitating transfer of control over responses to other stimuli. It is also the type of repertoire which can be used to facilitate the acquisition of generalized responses. The acquisition of these generalized responses is what is generally meant by concept attainment. The programmed visual demonstration of Archimedes' Law, referred to earlier, is an example of the use of the visual mode of instruction to produce concept attainment. It is certainly true that conventional instruction which is highly verbal has not exploited the possibilities of using visual means to promote concept attainment. It is an area that appears to merit more active exploration.

Retention

Are there a priori reasons for expecting a visual example to be better learned and therefore better remembered than the same example verbally stated? It seems to be part of our "common sense" experience that faces are recognized more easily than the names associated with them and that events which are witnessed are well remembered. What factors might account for this and have a bearing on whether to use a visual rather than a verbal example?

The rapid acquisition of responses to visuals may in part be accounted for by the generalized reinforcing properties of visual events discussed earlier. Moreover, a visual example, particularly those involving demonstrations, generally requires a longer period of time to be presented than does its verbal counterpart. The longer duration perhaps provides an opportunity for more frequent practice of responses, thus influencing how readily and how strongly they will be acquired. It is a tenable assumption and, certainly one which is amenable to empirical testing, that there are generally more responses under the control of verbal stimuli than there are under the control of visual stimuli. It may therefore be hypothesized that in using a verbal example, the appropriate response is more likely to meet with competition from other inappropriate responses than would be the case if a visual example were used. Responses to the verbal example may, thus, be less readily or less strongly acquired and also less well retained.

Thus, on the basis of these three assumed factors (reinforcement, frequency of response, and competability), the visual example may be better learned and as a corollary better retained.

Even if there may be theoretical reasons to assume more rapid acquisition and better retention of the facts illustrated in a visual example, the further problem arises of whether the generalized responses acquired on the basis of exposure to a series of visual examples are better learned and retained than are the generalized responses acquired on the basis of their counterpart verbal examples. Are there reasons to assume that concepts attained on the basis of either type of example will be better retained? This problem would also appear to merit investigation, particularly in view of the fact that in many subject matters, science for example, heavy reliance is put on the use of examples presented, in large part, in the visual mode.

Visualization

The total problem of analyzing student responses to visual presentations is particularly complex and difficult. Even more difficult is the problem of dealing with the production of visual images, visualization behavior, in the absence of instructor control over external stimuli. It raises a whole range of special issues undoubtedly requiring rather detailed and separate treatment and must necessarily receive passing mention here.

The capacity to "visualize" objects and events perceived in the past but no longer available as external stimuli could potentially be used by the student in making discriminations about the similarity between past occurrences and current ones. Such comparisons might be made in the active determination of the applicability of a generalized response to a current situation. Without available evidence on the matter, this capacity would not appear to have broad usefulness. Since visual images, like the originals they represent, are likely to be highly specific, they would appear to be less ideally suited as mediators of generalizations to a range of situations than their verbal counterparts. Nevertheless, if responses rather specific to a particular visual situation are to be learned and later emitted, the ready availability of a visual image of the identical or highly similar situation might prove effective as a cue for the desired responses. The visual image might have promise as a cuer of specific responses in out-of-the-classroom situations. Although it undoubtedly poses rather complex problems, how to create training situations which would produce such visualization behavior might prove a worthwhile research area. Relevant to this problem would be a consideration of the kinds of overt responses the student is expected to produce and how the cuing function or example function of the visual image might aid their production.

Distinctive properties of visual presentations have been described including: (a) the capacity of visuals to provide reinforcement; (b) the role visuals play in response generalization; (c) retention of visually perceived events; and (d) production of visualizing responses in the absence of external stimuli. It is in terms of some of these features that visuals may have a distinctive contribution to make to audio-visual instruction. While some of the functions visuals fulfill, which have been described in earlier sections, may be fulfilled equally well by their counterpart verbal stimuli, the preference for non-verbal visuals may be based on some of these considerations.

VISUAL REPRESENTATION

Once it has been determined that the use of a visual cue or visual reinforcement will facilitate the acquisition of particular responses, or that the use of a visual example will facilitate response generalization, it then becomes a practical matter of selecting or developing the appropriate visual materials. To be able to select the right visual for the right job, it is important to consider the relationships between visuals and their referents.

Visuals, live in the classroom or canned on film or television, can either stand for themselves or stand for something else. It is this representational capacity which makes visuals effective both as cues and as examples. Visually perceived physical events can not only stand for themselves, they can also represent other physical events, or they can represent verbal propositions. If, for example, a hydraulic system is used in a science demonstration and students are required to make visual discriminations about its parts, the visual can be said to stand for itself. The student may be required to practice responses to the visual presentation itself. If, however, the student is required to interpret or describe the occurrences in the demonstration, the visual may now represent or stand for a verbal proposition describing physical events covered by Pascal's Law. In this instance, the student is expected to respond to the example explained by an abstract proposition. Its use as an instance subsumed under a general principle is intended to establish generalization of responses. The presentation can

also by analogy stand for other physical phenomena or, more precisely, verbalizations about other physical phenomena as, for example, "electromotive force." The control of responses he practices must ultimately be transferred from visual or verbal stimuli relevant to hydraulic phenomena to verbal stimuli relevant to the concept of electromotive force. Whether the visual stands for itself, for other physical phenomena, or for verbal propositions depends, therefore, on how the student is required to respond to them. These variations in referent also determine whether the visual is used so that responses can be brought under its control or whether it is used so that control can be transferred from it to other stimuli.

Graphic materials represent one of the most frequent and typical uses of physical objects standing for something else. A wiring diagram stands for electrical circuits. A table of organization consisting of a series of blocks and lines may stand for the reporting and supervising behavior of large numbers of people in a business organization. In the use of such graphic materials, the student is expected to respond to their physical properties. They are chosen primarily because students typically already have in their repertoire responses to many of their physical dimensions, or they can easily acquire them. Lines, for example, can "mean" connecting things; boxes can "mean" including and excluding things. Once these materials cue these responses, the responses can then be brought under the control of the relevant verbal referent, for example, statements about the flow of information from the marketing department to the engineering department.

As we shall refer to them shortly, these "analogous" types of representation can be used in instruction because of available student responses to them. Student responses already under the control of the spatial, temporal, or sequential properties of the visual, or those easily brought under their control, can then be easily transferred to other stimuli which are relevant to the subject matter. Whatever the type of representation, we exploit them because they are able to exercise control over responses we wish the student to practice and they help to arrange for the transfer of control to other stimuli whenever it is appropriate to do so. Visuals are selected for these purposes because they either can do the job which verbal materials cannot or they can do a more efficient job.

Two dimensions which characterize the relations between visuals and the referents they represent and which may importantly affect the effectiveness of instruction are "realism" and "literalness." Both may affect the cuing/reinforcement and

the example functions of visuals, in turn affecting the acquisition, retention, and transfer of responses.

Realism

In using instructional TV or instructional films visual materials are often used to represent aspects of the physical world. Such representation has been generally described as realistic when it has involved the reproduction of physical objects on film or in photographs with great fidelity. When reproduced in drawings, paintings, or animation the representation is described as being less realistic.

For the purposes of this discussion, it is assumed that film or TV can faithfully reproduce real world objects. Confidence in this assumption can at all times be supported by objective evidence indicating whether students respond similarly to the representation and to the referent. For instructional purposes, the primary concern must be whether the representations can adequately cue the responses which are known to occur to the original and whose practice is now required in the learning situation. The representation which succeeds in this regard may be realistic or non-realistic.

The transcription of physical events on video tape or on film do in all probability attain sufficient realism to cue most if not all the responses in which we may be interested. An animated or non-realistic sequence of an expanding metal bar may conceivably do as good a job of cuing the response "expands" as a live, filmed, or taped version. There may remain some question, and it is important to determine empirically in each instance, whether the use of drawings, animation, and other graphic or pictorial materials can as successfully cue responses as their realistic counterparts. To the extent that they reproduce the physical dimensions appropriate to the response to be cued, they may be capable of serving this purpose. As to the reinforcement properties of graphic materials, based on the considerations discussed in an earlier section, it might be pointed out that non-realistically portrayed events may be less reinforcing in either the confirmation or motivational sense than real events or realistic reproductions of them.

During an actual televised lesson on "heat," a ball and ring experiment was used to demonstrate the effects of heat on solids. The ball was inserted through

a ring and then heated. After it was heated, it could no longer be extracted from the ring. The visible effort of the instructor pulling the ball against the ring, aided by an audio clank, produced audible gasps from an eighth grade student audience. There is reason to doubt that an animated version of the same demonstration would have been as reinforcing, in the motivational sense.

While non-realistic visual representations of objects and events may be capable of serving a cuing function and an example function, there may be doubts as to whether the generalized reinforcing properties of visual events may extend to them.

Literalness of Representation

A second important dimension of visual representation has to do with the relationship between a visual example and a typically verbal proposition it is intended to illustrate. The verbal proposition may contain within it reference to physical phenomena, to abstract phenomena, or to a combination of both. Visuals vary considerably in the extent to which they can parallel or reproduce these verbal referents. The very same visual example which directly and completely reproduces a statement of fact, will only indirectly reproduce a general proposition under which it is subsumed. Thus, the literalness of a given visual example varies depending on the referent it is intended to represent.

The dimension of literalness can be further explicated by a description of the following four types of visual representation:

Direct representation. - It is often desirable to represent by means of a direct visual example something that has been stated verbally. For example, in science instruction it might be helpful to demonstrate in visual terms the physical phenomenon of a bending bi-metal bar described by the verbal statement, "the bi-metal bar bends as it is being heated." The bending of a bi-metal bar following the application of heat to it is actually shown occurring. The visual demonstration or representation literally reproduces or reconstructs what is referred to in the verbal statement or proposition. Thus, visual and verbal presentation in this instance directly parallel one another. Transfer of control over responses from visual to verbal stimuli, or vice versa, should be possible without lengthy intermediary instructional sequences.

If a visual example is one of a series of equally direct representations of a proposition (e.g., several examples of "liquids boil when heated"), a generalized response may easily be acquired. If, on the other hand, one or more of the examples depart from directness, the discrimination of similarity among examples may less readily occur and there may be a failure in generalization.

Indirect representation. - Sometimes when the referent described in a verbal proposition is a physical event which is unobservable or when the referent is an abstraction, indirect visual representations are often used. Indirect visual representations can be used in the following situations: (1) where the physical referent in a verbal proposition is unobservable, it may be indirectly represented through results or effects; for example, the amount of expansion which solids undergo upon being heated is minute and unless magnified not observable to the naked eye; a ball and ring experiment in which the heated ball no longer passes through a ring, might be used to represent the expansion phenomenon; here, however, what is being represented is the inability of the ball to be extracted from the ring following the application of heat to it; thus it is the effect of expansion which is being represented directly; the expansion itself is only indirectly represented; (2) similarly, general principles cannot themselves be directly represented; they can, however, be indirectly represented through specific instances; for example, the general proposition "all matter expands when heated" cannot be directly represented; but a specific instance of a gas or a liquid expanding can be demonstrated and these demonstrations then serve as indirect visual representations of the more general verbal proposition; (3) abstract ideas also cannot be directly represented but can be adequately represented indirectly by concrete instances; in talking about charity, to use a non-concrete example, scenes of material help being given to needy persons can be presented visually.

In all three instances cited, where the verbally described referent is unobservable, is a generalization, or is abstract, indirect visual representations can be used. However, the visual example does not directly reconstruct or reproduce the verbal statement the student is expected to acquire. By itself, the visual represents this statement only indirectly. Further intermediary sequences are therefore needed to transfer control from the indirect visual representation to verbal propositions. These sequences are likely to be more lengthy and complex than those required in the case of direct representations.

Response generalization may be as easily acquired for indirect examples as for direct examples if there is sufficient similarity among the indirect examples. A mixture of direct and indirect examples, however, might be expected to provide less favorable conditions.

Analogous representation. - Another way verbally described referents can be represented is by means of analogy. Other physical and visually perceived phenomena which operate in analogous fashion or have analogous properties can be used to represent the phenomena under consideration. "Electromotive force," for example, cannot itself be directly or literally represented. We may, however, use a hydraulic system which operates in analogous fashion to represent it. Most graphic illustrations, such as curves or bar charts are analogous representations. Physical variations in the visual representations are analogous to variations in the phenomena to be represented. So, for example, the pie chart is made up of areas of varying size that are proportional to the phenomena that are represented by it.

Problems in transfer of response control and in response generalization discussed in connection with direct and indirect representations are also applicable to analogous representation.

Arbitrary representation. - There are many occasions when short-hand visual representations are desired for referents which may or may not be capable of direct, indirect, or analogous representation. Phenomena such as symbols or visuals which bear no physical or even logical relationship to the referent can nevertheless be used to represent it. The representation is arbitrary and is established by convention only. The symbol X may stand for the amount of rainfall in India; or the barber pole can stand for the barber shop; or a crest may stand for a family; a balance scale can stand for the abstract idea of "justice," etc.

The ease with which responses may be acquired and generalized may be influenced by both the realism and the literalness of visual representation. It is therefore important in instructional situations employing visual materials that close, analytic attention be paid to the nature of the relationship between a referent and its visual representation, and to variations in these dimensions of representation.

CONCLUSION

When we say that a picture is worth a thousand words, we apparently mean quite a number of things. We mean that non-verbal, visual materials can be used to aid students to learn, retain, and transfer responses. Their value in promoting these functions derives from their capacity to cue and to reinforce specified responses under specified conditions. When visual materials, rather than verbal materials, are selected to cue and/or to reinforce responses, it is because they can do a better job than words, e.g. take less time to attain a specified criterion. Or they can do a job which words cannot do. Evaluation of visual presentations is thus response-oriented.

The efficiency of instruction is a function of the explicit control exercised over the conditions under which students respond. This applies just as much to visual presentations as to verbal presentations. We appear to know a good deal less about responses to visuals than we do to words. But, if student viewers can be stimulated to make explicit responses, either overtly or covertly, to visual materials, there is a higher probability that the responses they make will be the desired ones. The practice of appropriate responses in appropriate contexts appears, on the basis of research on film, TV, and programmed instruction, to be an important condition for effective learning.

There are two general classes of visuals which are used to stimulate student response. They are criterion visuals and intermediary visuals. Criterion visuals are those which appear either in achievement tests or in out-of-the-classroom situations. They are generally integral parts of the subject matter being taught. The criterion visuals are used in the learning situation so that students can practice making discriminations about them or can practice making either verbal or motor responses to them. These are the responses which students are expected to make in the criterion situation which contains the very same visuals or highly similar ones to which the newly acquired responses will generalize.

Intermediary visuals, on the other hand, consist of those stimuli which typically already control responses or under whose control these responses can be readily

brought. These visuals will not be encountered in a test nor out of the classroom. Their role is essentially an instrumental one, that of facilitating the practice of specific responses. Their primary purpose in the learning situation is to cue and also to reinforce specific responses which may then be brought under the control of other, usually verbal stimuli.

We can identify two general functions which both classes of visuals serve. They serve either a cuing/reinforcing function or an example function. Visuals can be used to cue and to reinforce specific responses which students are required to practice. Visuals can also be used as examples along some generalization dimension. Students can acquire a generalized response, e.g. understanding of a concept, by being exposed to a series of visual examples which bear a structural or functional relation to one another and also bear a relation to the concept they illustrate. Responses to visual and/or verbal examples, can lead to the acquisition of such a generalized response.

What kinds of responses do students make to these various kinds of visuals and what instructional functions do these responses serve? Students may be required to practice making verbal responses, visual discriminations, and non-verbal motor responses to visual presentations. There are two purposes for students practicing these responses. First, they are the responses designated by lesson objectives as being criterion responses. They are the responses we expect the student to make to a test or in an out-of-the-classroom situation. Second, they are intermediary responses which must be acquired prior to and on the basis of which criterion responses can later be made. They may or may not be related to the subject matter. In either case, the student must learn to make them before he can make the complete criterion response. An important instance of these intermediary responses are those uniquely required by <u>visual</u> presentations. These are the discriminations about the objects and events the student must already possess or acquire during the course of a visual presentation. Without being able to discriminate among the spatial, temporal, or sequential units of the visual presentation, the student will be unable to make or acquire further responses to the relevant parts of the presentation. He will fail, for example, to make the connection between verbal portions of a lesson and the visual portions to which they refer and on which they are in turn dependent.

Both criterion and intermediary responses can be prompted to occur in many instructional situations by either verbal or visual stimuli. In most practical

situations both are likely to be used, sometimes simultaneously and sometimes in succession. This paper has confined itself to a consideration of a number of factors operative when visual stimuli are used. These have included on the one hand such logistical considerations as the number and complexity of responses a given visual might serve to cue. On the other hand, they have included such learning considerations as reinforcement, retention, and generalization of response. If a picture is worth a thousand words, it is in terms of these two types of considerations. Perhaps it will always remain an empirical matter just how many words any given picture is worth. For anyone willing to pursue such an accounting venture, it should be easy enough to determine empirically how many words it actually takes to match a visual's capacity to aid students to acquire, retain, and transfer specific responses or classes of responses.

A more worthwhile venture would appear to be -- finding out in analytic and systematic ways how the control of student behavior by visual means can aid the effectiveness of instruction.